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List of Agricultural Best Management Practices for the Imperial Irrigation District

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INTRODUCTION AND PURPOSE

In December 1993, the California Regional Water Quality Control Board (RWQCB), Colorado River Basin, Region 7, requested that the Imperial Irrigation District (IID) accelerate actions to improve drainage waters in the Imperial Valley. The major pollutants of concern are suspended solids (silt) and insoluble pesticides, selenium, soluble pesticides, fertilizers, and bacteria.

In response to the RWQCB's request, IID proposed to develop and implement a three-part drainwater quality improvement program (DWQIP) consisting of: (1) a water quality monitoring program, (2) best management practices (BMPs), and (3) an educational program for farmers operating within the IID service area. The DWQIP will provide a framework for improving the quality of irrigation drainage waters originating from agricultural lands within the IID service area. In December 1994, IID contracted with Jones & Stokes Associates to assist in developing and implementing the DWQIP.

The second part of the DWQIP involves developing and implementing an agricultural BMP program for IID. This report presents the results of the first task (Task 1) in the development of the BMP program. The report includes a literature review of known and available BMPs that could improve drainwater quality and a conceptual list of recommended BMPs applicable to the Imperial Valley. The second task of the BMP program will include a workplan to test the sediment reduction and cost-effectiveness of two selected BMPs. The results of the testing program will be incorporated into a comprehensive DWQIP document.

SCOPE OF THIS REPORT

The BMP program will target those practices that have the greatest potential for reducing total pollutant loading from agricultural operations and are feasible for wide-scale implementation in the Imperial Valley. The goal of Task 1 was to identify practices with potential and demonstrated effectiveness at improving the quality of agricultural irrigation drainwater. The focus was directed at practices a farmer in the Imperial Valley could implement to reduce the available pollutant amount or transport of pollutants delivered to surface and subsurface drainage. All relevant and feasible on-farm BMPs, as opposed to off-farm practices (e.g., instream, institutional incentives, and legal restrictions), were considered.

BMP EVALUATION PROCESS

Applicability of Identified BMPs to the Imperial Valley

Considerable attention has been directed toward surface and subsurface drainage problems associated with irrigated agriculture in California over the last 10 to 15 years. The Imperial Valley, Sacramento River, San Joaquin River, and Delta drainage areas have been the focus of considerable research (Rhoades et al. 1989, Boyle Engineering 1986, and Imperial Irrigation District 1978). Special studies (U.S. Department of Agriculture 1979, 1989, and 1992 and California Resources Agency 1981) have characterized the design specifications, efficiencies, effectiveness, and costs of agricultural BMPs for irrigated land in particular. Although agricultural lands in the IID service area have unique characteristics that must be considered in evaluating and selecting BMP designs (e.g., arid climate, soil properties and drainage patterns, regional farming practices, and water supply and delivery parameters), in general, most BMPs that have been developed and refined for irrigated agriculture around the world are applicable to the Imperial Valley.

Development of the Lists of BMPs

Lists of potential BMPs were developed for each of three water quality problems of concern in the Imperial Valley, including sediments, pesticides, and toxic constituents (i.e., salt, selenium, and boron). These BMPs are summarized in Tables 1, 2, and 3. Evaluation of BMPs involved a three-fold process of gathering information, establishing evaluation criteria, and rating BMPs based on the criteria. The lists of BMPs were developed with input from IID staff, agency and research personnel involved in agricultural operations of the Imperial Valley, and published reports (Knell, O'Halloran, Cameron, and Bali pers. comms.).

Selected evaluation criteria include effectiveness, applicability, cost, and feasibility. The performance of a specific BMP is intricately linked with site-specific characteristics such as soil types, climate, irrigation methods, cropping patterns, and tillage practices. For the purpose of this report, the rating process assumes that existing, or baseline, conditions in the Imperial Valley consist of conventional furrow and border irrigation practices. Since the IID project area is large and site-specific farm characteristics vary, the evaluation criteria were rated using a simple low (L) to high (H) scale. Ratings were assigned based on background research, where available, and professional judgement based on similar project results.

The evaluation criteria are primarily rated according to the most predictable results under a range of environmental and farm conditions. Effectiveness and applicability are rated based on the benefits to environmental quality after implementation. The cost criterion rating is based strictly on the additional annualized capital, operating, and maintenance costs to the farmer for

Table 1. Continued

Best Management Practices	Evaluation Criteria Ratings (Low, Medium, High)			
	Effectiveness	Applicability	Cost	Feasibility
Management-Based Controls				
21. Polymer Treatment	M - H	L - M	L - M	M
22. Reduced Tillage Practices	L - M	M	L	M
23. Conservation Tillage Practices	M	M	L - M	M
24. Conservation Cropping Practices	L - M	M	L - M	M
25. Conservation Planning	M	M - H	L	M
26. Land Fallowing[c]	H	L - M	H	L
27. Land Retirement[c]	H	L - M	H	L

[a] BMPs 13 and 14 are included on one data sheet in Appendix A.
[b] BMPs 17 and 18 are included on one data sheet in Appendix A.
[c] BMPs 26 and 27 are included on one data sheet in Appendix A.

Table 1. List of On-Farm Best Management Practices for Sediment Reduction

Best Management Practices	Evaluation Criteria Ratings (Low, Medium, High)			
	Effectiveness	Applicability	Cost	Feasibility
Structural Controls				
1. Improved Drop Boxes	L - M	H	L	M - H
2. Portable Check Dams	M	M	L	M
3. Furrow Dikes	L - M	M	L	M
4. Filter Strips	M - H	L - M	L - M	M
5. Grass-Lined Swales	M - H	L	L - M	L - M
6. Sediment Traps	M	M - H	L	M
7. Sediment Basins	M - H	M	M	M
Irrigation-Based Controls				
8. Improved Irrigation Scheduling	L - M	H	L	M
9. Gated Pipe Irrigation	L	H	M	M
10. Shortened Furrows	L - M	L - M	M	L - M
11. Cut-Back Irrigation	M	M - H	L	M
12. Cablegation	M	M	M - H	L - M
13. Land Leveling, Slope Adjustments, and Tail End Flattening[a]	M - H	M - H	M - H	M - H
14 Dead Leveling[a]	H	M - H	M - H	M - H
15. Surge Irrigation	M	M	M - H	L - M
16. Tailwater Recovery Systems	H	M - H	M	M
17. Germination Sprinkler Systems[b]	H	M	M - H	M - H
18. Irrigation Sprinkler Systems[b]	M - H	M	H	M
19. Low Energy Precision Application (LEPA) Sprinkler Systems	M - H	M	H	M
20. Drip/Trickle Irrigation Systems	H	M - H	H	M

Table 2. List of On-Farm Best Management Practices for Pesticide Reduction

Best Management Practices	Evaluation Criteria Ratings (Low, Medium, High)			
	Effectiveness	Applicability	Cost	Feasibility
Runoff and Suspended Sediment Controls				
1. Reduced Till, Check Dams, Traps, and Filter Strips	L - M	M - H	L - M	L - M
2. Sediment Basins and Wetlands	M - H	L - M	M - H	M
Irrigation-Based Controls				
3. Improved Efficiency	M	M	L - H	L - M
4. Improved Conservation	M - H	M	M - H	M
Integrated Pest Management Approach				
5. Improved Pest Monitoring	M	H	L	M
6. Improved Application - Equipment, Timing, Spot Spray, Stagger, Banding	M - H	M	M - H	M
7. Improved Chemicals - Toxicity, Formulations	M	L - M	M - H	M
8. Mechanical Control - Cultivation, Pest/Habitat Destruction, Trapping	M	M - H	L - M	M
9. Crop Management - Rotation, Selection, Canopy Management, Pruning, Covers	L - M	M	M	M
10. Bio-Control - Microbes, Enemies, Nursery Crops, Pheromones, Autocide	M	M	M	M
Farm Management-Based Controls				
11. Improved Facilities - Storage, Loading, Anti-Backflow, Rinsing, Disposal	M - H	M - H	L - M	M - H
12. Organic Farm Methods	M - H	L - M	L - M	L - M
13. Land Fallowing or Retirement	H	L - M	H	L

Table 3. List of On-Farm Best Management Practices for Toxics Reduction

Best Management Practices	Evaluation Criteria Ratings (Low, Medium, High)			
	Effectiveness	Applicability	Cost	Feasibility
Irrigation Management Controls				
1. Improved Efficiency	M	M - H	L - H	M
2. Improved Conservation	H	M	L - H	M
3. Soil Amendment - Gypsum, Ripping, Polymers	? - L	L - M	L - M	L - M
4. Improved Furrow Design - Ridge Tilling, Bed Shape	L	L - M	L - M	L - M
Irrigation Methods Controls				
5. Improved Scheduling	L	M - H	L	H
6. Cutback Methods - Surge, Cablegation, Run Length	L - M	M - H	L - H	M - H
7. Leveling, Pump Back	L - M	M - H	M - H	M
8. Sprinkler - Conventional	M	M	M - H	M
9. Sprinkler - LEPA	M - H	M	H	M
10. Surface Drip/Trickle Irrigation	H	H	H	M
11. Subsurface Drip/Trickle Irrigation	H	M - H	H	L - M
Management Controls				
12. Conservation Planning	L - M	M - H	L	M
13. Crop Selection - Salt and Drought Tolerance, Uptake of Toxics	M - H	L - M	M	L - M
14. Land Fallowing or Retirement	H	L - M	H	L

the BMP. The cost ratings do not reflect anticipated returns on the investment from input savings and production improvements. The feasibility rating is based on a qualitative "averaging" of the other three criteria as well as consideration of the historical use and acceptance of a listed BMP in the Imperial Valley and other areas of California; the feasibility rating represents a judgement regarding the practicability of implementation of each of the listed BMPs.

Sediment Reduction BMPs

In addition to the lists of BMPs included in Tables 1 through 3, this report includes data sheets for the identified sediment reduction BMPs. These data sheets are included in Appendix A. The data sheets provide a brief description of the BMP and summarize information on design considerations, advantages, limitations, and specific costs. The BMP-testing program will focus on BMPs that reduce sediment loads in irrigation drainwater through reduction of sediment on-farm. The data sheets are intended to provide additional information for selecting priority BMPs for testing.

Evaluation of BMP effectiveness was based primarily on the demonstrated results for controlling erosion at the source (i.e., in the field). BMPs that reduce the amount of mobilized sediment were given a higher effectiveness rating than BMPs that prevent the transport of mobilized sediment into the drains. Advantages and limitations were evaluated from the farmers' perspective as gains or losses derived from implementation. Costs tend to be highly variable depending on existing onsite facilities, the size of the farming operation, and existing farming practices. Cost evaluation criteria in the lists of BMPs (Tables 1-3) reflect only the cost of implementation, except where returns on the investment in BMPs are specifically noted and generally recognized in the industry. The return on the investment in a BMP will depend largely on market forces that govern profit margins.

PRELIMINARY RECOMMENDATIONS

Selecting BMPs for Implementation

Effectiveness for Control of Target Pollutants of Concern

In selecting BMPs to recommend to farmers, primary consideration should be given to BMPs that target the pollutants of most concern to regulatory agencies, agricultural operators, and environmental interest groups. The State Water Resources Control Board (SWRCB) established water quality goals for Class C - Constructed Agricultural Drains in the Water Quality Control Plan for Inland Surface Waters (ISWP). Provisions within the ISWP were the subject of a lawsuit brought against the SWRCB in 1994 and, consequently, the plan is currently undergoing review for readoption in the future. However, the water quality goals established in the plan are still useful in providing guidance for a BMP implementation plan for the Imperial Valley.

Of particular relevance to the IID are the ISWP established goals for the pesticide DDT, selenium, and total suspended solids concentrations. DDT is no longer licensed for use; measures for control of DDT are not specifically identified in this report. Selenium is imported to the Imperial Valley primarily in Colorado River irrigation water supply, and most of the measures that improve water use efficiency and conservation will have positive benefits for control of selenium pollution. Total suspended solids are derived primarily from soil erosion; implementing the BMPs identified in the lists (Tables 1-3) and data sheets in Appendix A that are effective at controlling these sediments should be considered a priority.

Feasibility Rating

With exceptions for BMPs that have been developed for steep slopes, northern climates, or particular soil properties, most of the commonly utilized BMPs could be adapted for use in the Imperial Valley. Therefore, the overall feasibility rating is an important factor in the success of a BMP program because it accounts for the cost to the farmer and BMP effectiveness. Farmers' voluntary implementation of BMPs will depend on the anticipated benefits to be gained from implementation in the form of reduced material and labor input, rate of return on the investment, ease of use, and potential effects on crop yield. BMPs that provide little incentive to the farmer are not likely to be adopted voluntarily. As a side note, an effective public information program to inform farmers of the current knowledge regarding costs and benefits of specific BMPs will be an important part of gaining acceptance and adoption of any pollution control practices.

Magnitude of the Problem Source

Achieving the greatest water quality improvement requires consideration of the magnitude of the problem source. The selection of BMPs to recommend for adoption by farmers should target the most significant sources of pollutants of concern. An effective approach will consider the amount of sediment generated by a given farming practice, the extent of land surface area that contributes to the problem, and the number of farms that contribute to the problem. The quantity of pollutants that are attributed to a given farming system is related to the whole spectrum of factors previously mentioned. Some general considerations include less-than-optimal farming practices that result in poor water-use efficiency, excessive tailwater runoff and erosion, deep percolation losses to subsurface drains, and excessive losses of pesticides and other farm chemicals to the environment.

Comprehensive Management

BMP selection shall consider the cumulative benefits derived from a comprehensive management approach to each farm's pollution problems. BMPs that are effective at controlling more than one target pollutant should be considered first. Additionally, cumulative benefits can be derived and management flexibility can be substantially enhanced by implementing two or more BMPs in series. In many cases, the cumulative reduction in sediment erosion achieved by implementing BMPs in series will be greater than the sum of the reductions when implemented individually (U.S. Department of Agriculture 1989). Integrated pest management (IPM) practices are also highly recommended practices that are most effective when adopted in a comprehensive approach. The cumulative benefits of incorporating BMPs in a comprehensive management plan have generally proven profitable to the farmer over the long term as well. The most effective BMP program will be one that considers all aspects of the farming operation and resolves to combine solutions that provide the greatest incentives for the farmer.

Pollutant Load Versus Pollutant Concentration

In arid climates such as the Imperial Valley, the influence of a given BMP on pollutant load versus pollutant concentration and its associated environmental impacts also must be considered. In general, it is considered an important goal to decrease the total load of pollutants that enter a water body. However, high evapotranspiration demands in arid climates tend to lead to evaporative concentration of materials in the water and soils. In addition, irrigation management for salts can cause water and salt transport by deep percolation to subsurface drains.

High pollutant concentrations tend to produce direct adverse environmental impacts to the life processes of aquatic organisms and wildlife in the form of lethal toxicity and bio-accumulation in the food chain. Total pollutant loads, on the other hand, typically affect or are representative of physical characteristics such as sedimentation in streambeds, total salts entering the Salton Sea, long-term soil loss, and the ability of natural processes to absorb or detoxify a material. In the Imperial Valley, water quality goals have been established to reduce concentrations in general and specifically lower the total suspended solids concentration. Consequently, due consideration should be given to the overall effect that wide-scale implementation of BMPs will have on concentrations versus loading impacts.

Selecting BMPs for Testing

The selection of BMPs to be tested for effectiveness and applicability for wide-scale implementation in the Imperial Valley should be based on the selection criteria discussed previously. Additionally, a range of scientific criteria needs to be identified to establish a valid testing program. Key steps for any testing program that compares the performance (e.g., percent pollutant reduction) of different BMPs to existing conditions are listed below:

- establishing data quality objectives (i.e., what to test for, what is trying to be proved, minimum detectable effect, and acceptable level of uncertainty in results) and
- establishing the experimental methods to be used (i.e., experimental design, sampling design, data collection, data analysis, and quality control and assurance).

Practical and financial considerations will also be of primary importance in selecting the BMPs to test. A representative list of criteria could include:

- Budget and personnel constraints (e.g., approximate costs for equipment and lab work).

- Timeframe required to achieve test results (i.e., testing crop rotation differences over several growing seasons versus the effects of two sediment traps during several irrigation sets).

- Identification of the need to conduct a "new" experiment versus testing of existing systems.

- Ability to extrapolate test results to a larger scale (e.g., test program between furrow characteristics versus comparisons of field-size treatments).

- Required amount of data to establish a definitive conclusion (i.e., sufficient information threshold).

- Influence on a BMP's performance from extraneous or uncontrolled variables that are not measured.

- Labor and material costs of different experimental alternatives. Possibility of teaming with other ongoing research projects.

- Ability to incorporate remote-sensing techniques and data analysis.

- Ability to integrate with and supplement a long-term trend monitoring program.

A clear definition of the testing program objectives, financial constraints, and the eventual use of test results in the development of a DWQIP will provide a firm foundation for designing an appropriate testing and analysis protocol.

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Appendix A. Data Sheets for Sediment Reduction Best Management Practices

BMP #1: Improved Drop Box

Targeted Pollutant: Sediment

Description:

The improved 42-inch drop box is designed to provide more effective control of tailwater discharge than conventional-size drop boxes. Drop boxes control the discharge of field drainage from the tailwater ditches to the drainage ditches. Appropriate sizing and use of grade boards minimize erosion by reducing tailwater velocities and allowing sediments to settle out in the tail ditch. The drop box maintains the elevation of tailwater in the tail ditch so that erosion at the end of the field is minimized.

Design and Sizing Considerations:

Designs need to consider relevant factors affecting tail water runoff and volume to allow control of field drainage, prevent flooding of the fields, and prevent erosive velocities. Wider grade boards reduce tail water velocity to maintain spill rates. Drop boxes need to be installed such that water does not back up into the field and lead to high water temperatures that can scald crops. Larger tail ditches may be required and damaged drop boxes replaced.

Effectiveness:

	Amount	Transport
Sediments	○	●
Soluble Pesticides	○	○

Sediment Reduction Efficiency: unknown

Advantages:

* Improves drainage
* Cost-effective
* Improves management
* I.D. Regulations exist for maintenance
* Keeps soil on farm when ditch graded properly
* No loss of land in production

Limitations:

* Does not always address source control
* Repair of field damage may be required

Cost: L

* Installation and materials minimal

Operations and Maintenance (O & M)
* Very low cost relative to other practices

References: Imperial Irrigation District 1978.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #2: Portable Check Dams	**Targeted Pollutant:** Sediment
Description: Portable check dams placed at intervals in the tailwater ditch. Dams minimize erosion by slowing water velocity, allowing sediment to settle out, and raising water level to prevent erosion at end of field.	
Design and Sizing Considerations: Simple check dams consisting of heavy plastic tarp, metal, or wood staked perpendicular to flow in the tailwater ditch. Dams need to be constructed such that water does not back up into the field and lead to high water temperatures that can scald crops. The use of more than one dam and a deeper tailwater ditch may be required depending the length of the ditch. Larger tailwater ditches may be required to accommodate the tarps.	
Effectiveness: Amount / Transport Sediments: ○ / ◗ Soluble Pesticides: ○ / ○ Sediment Reduction Efficiency: 40-60% [a] 60% [b]	Advantages: * Easy to use * Inexpensive * Cost-effective * Keeps soil on farm * No loss of land
Limitations: * Labor increased * Management increased * Could hold back water into fields * Shallow slopes may limit applicability	Cost: L * Installation - $5-10 per acre per crop [a] O & M - $4-7 per acre per crop * Increased management and labor. Relatively inexpensive strategy.
References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992. [b] U.S. Department of Agriculture, Soil Conservation Service 1979.	

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #3: Furrow Dikes	Targeted Pollutant: Sediment

Description:

Small dikes are created in furrows with an attachment to tillage equipment. Dikes slow the irrigation flow which allows more water to infiltrate and sediment to drop out.

Design and Sizing Considerations:

Furrow dikes, like tailwater ditch tarps, need to be implemented after consideration of irrigation flow rates, furrow characteristics, irrigation methods, and cropping practices.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	○	○

Advantages:

* Combines with other tillage operations
* Potential water conservation
* Potential yield improvement

Limitations:

* Limited documentation of use and effects
* May cause buildup of water on heavy soils

Cost: L

* $150 per dike attachment

References: Baumhardt et al. 1993.
Kranz and Eisenhauer 1990.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low, M = Medium, H = High

BMP #4: Filter Strips	**Targeted Pollutant:** Sediment

Description:

Grass border is maintained between the end of the fields and the tail ditch. Erosion control is provided as runoff diffuses out across the border and allows sediment to filter out.

Design and Sizing Considerations:

Filter strips must be carefully designed to achieve effective pollutant removal and prevent sheet, rill, and gully erosion. Generally created with grain, sudan grass, sorghum, or alfalfa.

Effectiveness:

	Amount	Transport
Sediments	○	●
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
65%[a]
40-65%[b]
60%[c]

Advantages:

* Effective at removing sediments and pollutants
* Low maintenance

Limitations:

* Could harbor pests that require control
* Land out of production
* Increased management

Cost: L to M

* $7.30 per acre per year for 5 years[a]
* Installation - $0.04 per foot for 30-foot-wide strip[b]
  O & M - $0.04-0.25 per foot
* Lost production unless cash crop used in filter.
* Can reduce size of other control measures needed.

References:
[a] U.S. Environmental Protection Agency 1993.
[b] U.S. Department of Agriculture, Soil Conservation Service 1992.
[c] U.S. Department of Agriculture, Soil Conservation Service 1979.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #5: Grass-Lined Swales	**Targeted Pollutant:** Sediment

Description:

Grass swales are wide, shallow, low-velocity channels used for conveyance of irrigation water Grasses filter and slow water to allow sediment removal and stabilize channels from erosional forces.

Design and Sizing Considerations:

Typical swale configuration for small flows consists of a 6-foot-wide flat bottom with 4:1 slope side walls. Depth of flow should not exceed the height of the vegetation

Effectiveness:

	Amount	Transport
Sediments	○	●
Soluble Pesticides	○	◐

Sediment Reduction Efficiency:
13-47% [a]
50% [b]

Advantages:

* Effective at removing sediments
* Keeps soil on farm
* May derive some forage benefits
* May provide wildlife habitat

Limitations:

* Land out of production
* Increased management
* Maintenance needed to maintain growth
* Potential for increased pests
* Limited use on minimal slopes

Cost: L to M

* Installation - $0.05-0.50 per foot [a]
  O & M - $0.03-0.15 per foot per year
* Installation - $0.17-0.56 per foot [b]
  O & M - $0.04 per foot per year
* $1.00 per foot per year annualized for a 10-year longevity [c]

References:
[a] U.S. Department of Agriculture, Soil Conservation Service 1992.
[b] U.S. Department of Agriculture, Soil Conservation Service 1979.
[c] U.S. Environmental Protection Agency 1993.

● = clear, demonstrated positive effect/influence.
◐ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #6: Sediment Traps	**Targeted Pollutant:** Sediment

Description:

Small sediment collection basins installed at spaced intervals along the end of a tailwater ditch. Designed to control erosion by slowing water near traps which allows larger sediments to settle where they can be removed periodically.

Design and Sizing Considerations:

Requires appropriate designs and management for site characteristics to be effective. Typical designs include I-slots, T-slots, or buried tailwater drain systems. Useful for fields that have been eroded at the ends of furrows or in the tail ditches. Most effective if each trap has separate outlet to the drainage ditch.

Effectiveness:

	Amount	Transport
Sediments	○	●
Soluble Pesticides	○	○

Sediment Reduction Efficiency:
0-95% [a]
70% [b]

Advantages:

* Effective at removing larger sediment particles
* Keeps soil on farm
* Low risk to yields
* More effective when combined with other practices

Limitations:

* Increased maintenance
* Increased labor costs
* Dewatering of sediments necessary before spreading

Cost: L

* Installation - $1,200 [b]
  O & M - $260 per year
* Depends on size, maintenance, and respreading requirements

References: [a] U.S. Environmental Protection Agency 1993.
[b] U.S. Department of Agriculture, Soil Conservation Service 1979.
Carter and Berg 1983.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #7: Sediment Basins	**Targeted Pollutant:** Sediment

Description:

Earthen detention and/or retention basin at the end of fields that slows water velocity to allow settling and collection of sediments. Sediment basins typically provide benefits for 10 years and lose effectiveness when 50 percent of the design storage volume has filled with sediment.

Design and Sizing Considerations:

Basins require appropriate design and management to be effective. Basins should be long and narrow for effectiveness. Basins should hold water for at least 2 hours to remove sediment. Residence time must be increased significantly to remove fines. General criteria affecting required capacity includes soil type, irrigation method, and cropping patterns.

Effectiveness:

	Amount	Transport
Sediments	○	●
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
90-95% [a]
65-95% [b]

Advantages:

* Extremely effective if properly designed
* Keeps soil on farm
* Can be used for tail water recovery system
* Wildlife habitat improvement
* May share costs with neighbors

Limitations:

* Sediment clean out expensive
* Land out of production
* Increased maintenance and management
* Attractive nuisance
* Dewatering of sediments necessary

Cost: M

* Installation - $18-200 per acre [a]
  O & M - $6-62 per acre

References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992.
[b] Brown et al. 1981.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #8: Improved Irrigation Scheduling

Targeted Pollutant: Sediment

Description:

Practices that maximize irrigation efficiency by improving the determination and control of water requirements for a crop. Generally implemented with a "checkbook" method that accounts for applied water and crop demand in a given time period. Improved methods take advantage of soil moisture monitoring, climatic variables, and computer models.

Design and Sizing Considerations:

Improved irrigation scheduling relies on data for soil moisture availability, allowable depletion before crop stress occurs, and evapotranspiration rates to perform a soil moisture balance for the field. Resources include the California Irrigation Management Information System (CIMIS), Department of Water Resources Mobile laboratories, and remote sensing of farm practices.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
20% [a]
30% [b]

Advantages:

* Improves irrigation efficiency and reduces losses to sub-surface drainage
* Potential for water savings
* Potential for reduced labor costs

Limitations:

* Increased management
* Potential for crop yield reduction from undetected plant stress

Cost: L

* $15 per acre per year [a]
* Installation - $2-10 per acre [b]
  O & M - $13 per acre

References: [a] U.S. Department of Agriculture, Soil Conservation Service 1989.
[b] U.S. Department of Agriculture, Soil Conservation Service 1989.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #9: Gated Pipe Irrigation	**Targeted Pollutant:** Sediment

Description:

Pipeline for irrigation that permits application water to furrows in a controlled system of mechanical gates. Effective at reducing erosion by improving management of water flow and reducing water losses to subsurface drainage and tailwater.

Design and Sizing Considerations:

Gated pipes are commonly made of aluminum, plastic, and flexible tubing. Specifications for construction are based on required flow rates, size of field system, and intended uses.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	○	○

Advantages:

* Allows improved irrigation management
* Leaves more land in production
* Easy to use

Limitations:

* Not effective unless coupled with proper management
* Increased maintenance

Cost: M

* Installation - $200-400 [a]
  O & M - $10-20

References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #10: Shortened Furrows

Targeted Pollutant: Sediment

Description:

Shorter furrow lengths are utilized to reduce the velocity and quantity of water needed to complete an irrigation set. Shorter furrows can increase uniformity of water distribution and may save water.

Design and Sizing Considerations:

Reconfiguring fields for furrow length adjustments depends on primarily soil characteristics. Furrow dimensions and flow rates are usually reduced to prevent increased runoff and erosion.

Effectiveness:

	Amount	Transport
Sediments	◗	●
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
25-30% [a]

Advantages:

* Improved water distribution uniformity
* Reduced subsurface drainage losses
* Potential water savings

Limitations:

* Reorganizing fields
* Need mid-field gated pipe
* Increased management
* Less efficient on low-permeability and cracking soils
* Less land in production

Cost: M

* $75-150 per acre per crop for ditch installation [a]
* $78 per acre per year [b]

References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992.
[b] U.S. Department of Agriculture, Soil Conservation Service 1989.
Hanson 1989.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #11: Cut-Back Irrigation Method	**Targeted Pollutant:** Sediment
Description: High initial furrow irrigation rates allow water to reach end of field quickly. Flow is then cut back to a fraction of the initial flow rates to allow time for sufficient water infiltration of soil. The cut-back method controls erosion by reducing the amount of tailwater runoff and time that flow is sustained at erosive velocities.	
Design and Sizing Considerations: An efficient cut-back irrigation method requires optimization of furrow flow rates, timing of cut-backs, and length of set times. Important factors affecting performance of the method include soil moisture, crop water requirements, and furrow length.	
Effectiveness: Amount / Transport Sediments: ◗ / ◗ Soluble Pesticides: ○ / ◗ Sediment reduction efficiency: 40-60% [a]	Advantages: * Reduces furrow erosion and runoff * Greater irrigation efficiency * Potential water conservation * No special equipment required
Limitations: * Increased management * More attention to scheduling	Cost: L * $4-9 per acre per crop [a]
References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992.	

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #12: Cablegation	**Targeted Pollutant:** Sediment

Description:

Automated water delivery system for irrigating furrows. The system consists of a stop plug, attached by cable to a motor driven take-up reel, that is allowed to travel inside gated pipe. Water delivery from the pipe is controlled by the position of the plug and its rate of travel inside the pipe. The technique effectively produces a cut-back irrigation method as the plug is reeled back to the head ditch. The cut-back method controls erosion by reducing the amount of tailwater runoff and time that flow is sustained at erosive velocities.

Design and Sizing Considerations:

An efficient cut-back irrigation method requires optimization of furrow flow rates, timing of cut-backs, and length of set times.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
40-60% *

Advantages:

* Reduces furrow erosion and runoff
* Greater irrigation efficiency
* Potential water conservation
* No special equipment required

Limitations:

* Increased management
* More attention to scheduling

Cost: M to H

* $1,000-$1,500 per field system *

References: * Trout 1992.

● = clear, demonstrated positive effect/influence.

◗ = positive effect/influence more likely overall.

○ = effect/influence negligible.

Cost Code: L = Low; M = Medium; H = High

BMP #13 and #14:

Land Leveling, Slope Adjustments, Tail End Flattening, and Dead Leveling

Targeted Pollutant: Sediment

Description:

Reshaping surface of irrigated fields to a constant grade. Allows uniform distribution of irrigation water and reduces velocity of water when slope is decreased. Sediment losses from dead-level basins are essentially eliminated.

Design and Sizing Considerations:

Proper leveling requires consideration of soil types and infiltration characteristics, length of runs, crops grown, water flow rates, and uniformity of grade. The ends of furrow irrigated fields and depth of tailwater ditches should be prepared to avoid head cutting erosion. The resistance to flow by the mature crop may be the limiting factor for border strip basin configuration. Dead-level basins are more applicable to close-growing crops such as hay, alfalfa, and small grains.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	◗	●

Sediment Reduction Efficiency:
10-50% [a]
50% [a]

Advantages:

* Improved irrigation efficiency and uniformity
* Improved crop production uniformity
* Adaptable to most crops
* Potential water savings
* Elimination of tailwater

Limitations:

* May require change in irrigation equipment and management practices
* Precision leveling difficult
* Inundation and crop health problems
* Large irrigation flows desirable

Cost: M to H

* $350 per acre [b]
  O & M - $40 per acre per year
* $32 per acre, per year [c]
* $500-1,000 per acre [d]

References: [a] U.S. Department of Agriculture 1992.
[b] U.S. Department of Agriculture 1979.
[c] U.S. Department of Agriculture 1989.
[d] O'Halloran 1992.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #15: Surge Irrigation	**Targeted Pollutant:** Sediment

Description:

Surge irrigation is an improved method where adjacent furrows receive alternating flushes of water until crop water requirements are met. Each flush only irrigates a portion of the total furrow length, allowing time for infiltration between flushes. Erosion control is achieved by a decreased furrow advance time and reduction of total runoff.

Design and Sizing Considerations:

The method is easily automated with surge valves and gated pipe. The optimum number of surges, advance flow rates, cut-back flow rates, and total on-times varies depending on field conditions and crop water requirements. Management of cut-back flow rates is more critical for fine textured and low intake soils.

Effectiveness:

	Amount	Transport
Sediments	◗	●
Soluble Pesticides	◗	◗

Sediment Reduction Efficiency: 80-87% *

Advantages:

* Improved irrigation efficiency
* Potential higher crop yields
* Automated and saves labor
* Dramatically reduces furrow water advance times
* Potential water savings

Limitations:

* High installation costs
* Increased management and maintenance
* Requires skilled training

Cost: M to H

* Installation - $700-1,200 per acre per crop *
  O & M - $15-35

References: * U.S. Department of Agriculture, Soil Conservation Service 1992.
Coupal and Wilson 1990.
U.S. Department of Agriculture, Soil Conservation Service 1986.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High.

BMP #16: Tailwater Recovery Systems

Targeted Pollutant: Sediment

Description:

Irrigation system improvement where tailwater or subsurface drainage water is pumped back to head of field or to another field and either reapplied or blended with fresh source water before application. System controls erosion by essentially eliminating tailwater.

Design and Sizing Considerations:

A collection basin or sump is required to collect tailwater and a pump is required to convey water back to head ditch. If properly designed, pump can be used to redistribute sediments that deposit in sump back onto the field. It has been demonstrated that crop scalding is not a problem if system is properly managed.

Effectiveness:

	Amount	Transport
Sediments	○	●
Soluble Pesticides	○	●

Sediment Reduction Efficiency:
90-95% [a]
60% [b]

Advantages:

* Water conservation
* Reclaims pesticides/nutrients in runoff
* Potential for complete tailwater elimination
* Keeps soil on farm

Limitations:

* Increased management and maintenance
* Land out of production
* Recirculation of pests and weeds
* Potential for scalding and burning

Cost: M

* Installation - $300-500 per acre [a]
  O & M - $28-60 per acre per year
* Installation - $140 per acre [b]
  O & M - $20 per acre per year
* $200-500 per acre [c]

References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992.
[b] U.S. Department of Agriculture, Soil Conservation Service 1979.
[c] O'Halloran 1992.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #17 and #18: Irrigation Sprinkler Systems	**Targeted Pollutant:** Sediment
Description: Pressurized irrigation system where water is applied through nozzles with various designs and applications. Several types of systems are common including hand set, solid sets, reel guns, linear move, and center pivot.	
Design and Sizing Considerations: Primary considerations in the design of a sprinkler system includes the field size, water infiltration rate, cropping patterns, and intended uses.	
Effectiveness: Amount / Transport Sediments ● ● Soluble Pesticides ◗ ● Sediment Reduction Efficiency: 25-35% - germination [a] 90-95% - established crop [a] 60% [b]	Advantages: * Irrigation efficiency and improved yield * Improved water distribution uniformity * More effective preirrigation method than furrow * Improved seed germination
Limitations: * High installation costs * Increased management and labor requirements * Increased power consumption * Potential for salt toxicity from spray	Cost: H * Installation - $200-700 per acre [a] O & M - $15-40 per acre * $300-500 per acre [b] * Installation - $450-2,210 per acre [c] O & M - $110 per acre
References: [a] U.S. Department of Agriculture, Soil Conservation Service 1992. [b] U.S. Department of Agriculture, Soil Conservation Service 1989. [c] U.S. Department of Agriculture, Soil Conservation Service 1979.	

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #19: Sprinkler - Low Energy Precision Application (LEPA)	**Targeted Pollutant:** Sediment

Description:

Adaptation to overhead sprinkler irrigation, linear move, or center pivot systems that involves a combination of pressurized irrigation and soil/crop management techniques. Sprinklers discharge water to individual furrows or crop rows close to the soil surface which improves efficiency and minimizes droplet evaporation. High intensity water applications must be managed to control erosion and runoff.

Design and Sizing Considerations:

Speed management of traveling components is important so that application volume does not exceed the soil infiltration capacity and increase runoff. Soil manipulation and residue management should be considered to increase soil surface storage capacity. Low erodibility potential of the soil should be a primary consideration. Furrow dikes may help improve LEPA irrigation efficiency.

Effectiveness:

	Amount	Transport
Sediments	●	●
Soluble Pesticides	◗	●

Advantages:

* Excellent irrigation efficiency
* Less water and labor inputs
* More efficient chemigation
* Potential yield improvements
* Avoids salt spray toxicity

Limitations:

* Erosion potential on erodible soils
* High installation costs
* Increased maintenance

Cost: H

* $30-40 per acre to upgrade conventional system [a]
* Investment generally recovered in several years from water and energy savings

References: [a] Fipps 1993.
Lyle 1994.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #20: Drip/Trickle Irrigation Systems

Targeted Pollutant: Water conservation

Description:

Pressurized irrigation system that applies filtered water at low pressure directly to the root zone of plants by means of orifices, emitters, porous tubing, or perforated pipe. Systems can be above or below ground surface. Drip irrigation reduces erosion by the elimination of tailwater runoff.

Design and Sizing Considerations:

Efficiency is maintained by frequent, low-volume irrigation. Drip tape can be placed on the surface or inserted in a subsurface application. Filtration devices are generally required to prevent clogging from suspended solids and algae in the water supply

Effectiveness:

	Amount	Transport
Sediments	●	●
Soluble Pesticides	●	●

Sediment Reduction Efficiency:
90-95% [a]
60% [b]

Advantages:

* Highly efficient and water conserving
* Reduces pests, weeds
* Increased production
* Precise application of chemicals
* Can be automated and reduces labor requirements

Limitations:

* High installation and maintenance costs
* Clogging of emitters
* Potential salt buildup in soil
* Excessive irrigation not obvious

Cost: H

* Installation - $1,500-2,000 per acre [a]
  O & M - $75-100 per acre
* $300-500 per acre, per year [b]
* $600-1,400 acre [c]
* $500-1,200 per acre plus O & M [d]

References:
[a] U.S. Department of Agriculture, Soil Conservation Service 1992.
[b] U.S. Department of Agriculture, Soil Conservation Service 1989.
[c] O'Halloran 1992.
[d] U.S. Department of Agriculture, Soil Conservation Service 1979.
Fulton 1991.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #21: Polymer Treatment	Targeted Pollutant: Sediment

Description:

Organic polymers (e.g., polyacrylamide) starch copolymers are added to irrigation water which increases the cohesive forces between soil particles and counteracts erosive forces. The polymers have also shown promise at improving saline soil stability and preventing cracking soils from swelling closed, thereby allowing greater water infiltration.

Design and Sizing Considerations:

Studies of polymers and their chemical properties are relatively new. Application rates of 1 lb/acre per irrigation have proven effective. Manufacturers of polyacrylamide are seeking approval as a soil additive. Presently used as a flocculent in food and wastewater processes.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
36-44% sediment reduction with a loam soil, San Joaquin Valley [a]
45-95% reductions in Idaho [b]

Advantages:

* Demonstrated effectiveness at increasing infiltration in shrink-swell soils
* Easy to use

Limitations:

* Relatively new methodology is not well documented
* Amounts required and the need for consecutive treatments are not known

Cost: L to M

* $15-20 per acre [a]
* $1.50 per acre per irrigation [b]

References: [a] McCutchan 1993.
[b] Lentz et al. 1992.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #22: Reduced Tillage Practices	**Targeted Pollutant: Sediment**

Description:

The soil conservation service defines reduced tillage as practices that limit the use of heavy farm machinery to only the operations required in growing and harvesting the crop. A goal to eliminate one cultivation per crop through reduced tillage is encouraged.

Design and Sizing Considerations:

Reduced tillage practices include working seed bed only enough to properly plant, avoid working soil when it is too wet, vary tillage depth from year to year, cultivate only to control weeds, and chisel when dry to break up plow pans

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	○	◗

Sediment Reduction Efficiency:
25-35% [a]
75% [b]
30% [c]

Advantages:

* Improved soil tilth, aeration, and water infiltration
* Maintains soil structure
* Protection from erosive water flows

Limitations:

* May need additional weed control
* Increased management

Cost: L

* Potential savings of $4-10 an acre per crop [b]
* Essentially no cost and potential savings. Greater reliance on pesticides may offset savings from reduced cultivations [c]

References: [a] U.S. Environmental Protection Agency 1993.
[b] U.S. Department of Agriculture Soil Conservation Service 1992.
[c] U.S. Department of Agriculture Soil Conservation Service 1979.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #23: Conservation Tillage Practices	**Targeted Pollutant:** Sediment
Description: Conservation tillage practices are tillage methods that provide suitable crop conditions while leaving at least 30% of the residue from the previous crop. Conservation tillage reduces erosion by limiting the exposure of bare soil to erosion and improving infiltration.	
Design and Sizing Considerations: The principal consideration of conservation tillage involves reduced use of the moldboard plow and harrow before and after harvesting a crop. Cultivation of weeds should also be minimized. Alternative practices rely on chisel plows, slip plows, sweep plows, disks, wheel track planting, and plow-planting operations.	
Effectiveness: Amount / Transport Sediments: ● / ● Soluble Pesticides: ○ / ◗ Sediment Reduction Efficiency: 2-20% [a] 47-100% [b]	Advantages: * Increases organic mater * May decrease need for fertilizers * Improves tilth, aeration, water infiltration * Profitable system over long term
Limitations: * Increased management * Increased weed and pest control * May need to adapt equipment	Cost: L to M * $0-50 per acre [a] * $17.50 per acre per year [c]
References: [a] U.S. Department of Agriculture Soil Conservation Service 1992. [b] Carter and Berg 1991. [c] U.S. Environmental Protection Agency 1993.	

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #24: Conservation Cropping Practices	**Targeted Pollutant: Sediment**
Description: A program of crop selection, rotation, and irrigation management that more effectively makes use of natural variables that can limit the amount of soil erosion. The program minimizes erosion through the cumulative effect of implementing component practices specific for each site.	
Design and Sizing Considerations: Cropping practices should consider selection of crops and their adaptations to soil moisture and salinity. Alternative practices include the use of more drought- and salt-resistant varieties, modified planting density, transplants versus seed, improved furrow and seed bed designs, and improved irrigation methods.	
Effectiveness: Amount / Transport Sediments ◗ ◗ Soluble Pesticides ◗ ◗ Sediment reduction efficiency: 40% *	Advantages: * Profitable system long term * Crop variety leads to stability of farm income * Increased soil fertility and less tillage * Increases or maintains water infiltration capacity
Limitations: * Increased management * Equipment changes may be necessary * Short-term profits may be sacrificed	Cost: L to M * Highly variable, depends on the degree of erosion, changes needed to the current cropping system, capital and labor changes required
References: * U.S. Department of Agriculture, Soil Conservation Service 1979. Sojka et al. 1992. Boyle Engineering 1986.	

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

BMP #25: Conservation Planning	**Targeted Pollutant:** Sediment

Description:

Conservation planning is an integrated planning approach for crop management, tillage and irrigation method selection, irrigation scheduling, and implementation of erosion control BMPs. This comprehensive planning and farm management approach allows more effective identification of problems, alternative solutions to the problems, and strategies for implementation of corrective measures. A comprehensive planning approach can minimize problems of erosion and sedimentation and reduce overall costs of implementing control measures.

Design and Sizing Considerations:

Conservation planning relies on effective problem identification and analysis of alternative solutions. Professionals associated with the agricultural trade industries (e.g., implements, irrigation equipment, chemical distributors), governmental agencies (e.g., Natural Resources Conservation Service, County Agricultural Extension, County Agricultural Commissioner), and consultants can provide planning services.

Effectiveness:

	Amount	Transport
Sediments	◗	◗
Soluble Pesticides	◗	◗

Sediment Reduction Efficiency: variable

Advantages:

* Proactive approach to problem resolution
* Long-term cost-effectiveness
* More timely surveillance of problems
* Better tracking of farm management variables
* May reduce reliance on chemicals

Limitations:

* Increased management
* Requires long-term commitment
* Short-term profits may be sacrificed

Cost: L

* Variable depending on increased management costs and long-term savings in production costs

References: U.S. Department of Agriculture, Soil Conservation Service 1992.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low; M = Medium; H = High

Table 1. List of On-Farm Best Management Practices for Sediment Reduction

Best Management Practices	Evaluation Criteria Ratings (Low, Medium, High)			
	Effectiveness	Applicability	Cost	Feasibility
Structural Controls				
1. Improved Drop Boxes	L - M	H	L	M - H
2. Portable Check Dams	M	M	L	M
3. Furrow Dikes	L - M	M	L	M
4. Filter Strips	M - H	L - M	L - M	M
5. Grass-Lined Swales	M - H	L	L - M	L - M
6. Sediment Traps	M	M - H	L	M
7. Sediment Basins	M - H	M	M	M
Irrigation-Based Controls				
8. Improved Irrigation Scheduling	L - M	H	L	M
9. Gated Pipe Irrigation	L	H	M	M
10. Shortened Furrows	L - M	L - M	M	L - M
11. Cut-Back Irrigation	M	M - H	L	M
12. Cablegation	M	M	M - H	L - M
13. Land Leveling, Slope Adjustments, and Tail End Flattening[a]	M - H	M - H	M - H	M - H
14. Dead Leveling[a]	H	M - H	M - H	M - H
15. Surge Irrigation	M	M	M - H	L - M
16. Tailwater Recovery Systems	H	M - H	M	M
17. Germination Sprinkler Systems[b]	H	M	M - H	M - H
18. Irrigation Sprinkler Systems[b]	M - H	M	H	M
19. Low Energy Precision Application (LEPA) Sprinkler Systems	M - H	M	H	M
20. Drip/Trickle Irrigation Systems	H	M - H	H	M

BMP #26 and #27: Land Fallowing and Retirement	**Targeted Pollutant:** Sediment

Description:

Land is taken completely out of agricultural production for a season or permanently retired. Seasonal fallowing can prevent erosion from wind and seasonal rains. Permanent retirement provides 100 percent reduction in sediments and irrigation based transport of salts and other soluble pollutants.

Design and Sizing Considerations:

Selection of land for seasonal fallowing requires consideration of potential maintenance during fallowing, cover crop to plant during fallow period, and pest management. Permanent land retirement requires only the consideration of willingness of seller and buyer.

Effectiveness:

	Amount	Transport
Sediments	●	●
Soluble Pesticides	●	●

Sediment Reduction Efficiency:
100%

Advantages:

* Long-term reduction in concentrations and total load of soluble salts and pollutants in surface waters.
* Effectiveness may be increased if large block of land is fallowed.
* Wildlife benefits from increased habitat

Limitations:

* Lack of economic incentive for landowner
* Local and state impacts on economy

Cost: H

* Long-term loss of production revenue
* Possible economic benefits of increased wildlife
* Possible revenue from water transfers to other uses

References: San Joaquin Valley Drainage Program 1990.

● = clear, demonstrated positive effect/influence.
◗ = positive effect/influence more likely overall.
○ = effect/influence negligible.
Cost Code: L = Low, M = Medium; H = High

6-9

INCENTIVE COMMITTEE REPORT TO THE WATER CONSERVATION ADVISORY BOARD

IMPERIAL IRRIGATION DISTRICT

DECEMBER, 1986

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INCENTIVE COMMITTEE REPORT TO THE WATER CONSERVATION ADVISORY BOARD

IMPERIAL IRRIGATION DISTRICT

DECEMBER, 1986

INCENTIVE COMMITTEE REPORT
TO THE WATER CONSERVATION ADVISORY BOARD

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SUMMARY

SUMMARY

S.1 INTRODUCTION

The long-term partnership of the Imperial Irrigation District and the farmers of the Imperial Valley created one of the most advanced irrigated farming areas in the world. Like all good partnerships there has been an ongoing need for open communications and an exchange of ideas for mutual benefit. In keeping with this tradition, the Incentive Committee was formed to study water conservation incentives.

The incentive approach to water conservation has been discussed over a period of years. It was presented in the 1985 Water Conservation Plan and in the Water Requirements and Availability Study (Parsons, 1985), and recommendations were made to further study this approach. While most farmers recognize the benefits of lowering the level of the Salton Sea, they agree that there must be a better alternative to the triple charge program. It is hoped that funding for incentive programs will come from those outside of the District interested in using and paying for water conserved in the IID.

In March 1986, the Water Conservation Advisory Board appointed a committee to investigate incentives and other measures to further encourage water conservation practices in the Imperial Irrigation District.

All incentive measures which were identified were reviewed and 38 various water conservation measures were received or developed in committee. They were divided into the five following incentive categories:

- Services by IID
- Incentives involving payments
- Tailwater-based program
- Incentives involving water rates
- Other incentive measures

An evaluation was made of each incentive measure identified. Thirty-one criteria were reviewed and 11 were chosen to evaluate the incentive measures. A list was made of both advantages and disadvantages for each incentive. Benefits and costs were studied but little data was available to assist with the study. Later when field trials of recommended incentives will have been made, there will be more meaningful data available in order to ascertain specific water conservation benefits and costs. In summary, this report presents the results of the incentive committee's work during the period from March 6, 1986 through August 5, 1986, for consideration by IID's Water Conservation Advisory Board and the IID's Board of Directors.

S.2 CONCLUSIONS AND RECOMMENDATIONS

Of the 38 various water conservation measures that were received or developed in committee, twenty-one measures and four variations to these measures were classified into incentives, and 13 others were general water conservation measures.

Tailwater-based incentives provide the specific incentives to increase efficiency and reduce losses, which is the primary goal of water conservation. A major disadvantage to most such programs is the cost of measuring tailwater to verify that goals are attained.

Changes are needed to permit deliveries to more closely match field use. They can be done either by employing techniques which would greatly improve the accuracy of ordering and delivering water, or by modifying the delivery system and its operation to allow deliveries to be terminated at the time field needs are satisfied, without canal spills.

There are two most promising types of tailwater-based programs. One pays a farmer for reducing tailwater within predetermined parameters and allows him to employ whatever means he chooses to save as much water as is economically feasible. The other program pays a farmer for effectively operating a pumpback system to predetermined specifications. A trial pumpback program is already in progress.

Programs which provide a service to farmers and which would make it practical for them to conserve water without additional expenses would also result in additional conservation. Services which are worthy of additional consideration include an irrigator training program. Another program would include improved training of zanjeros and other appropriate water personnel. It would also include a program by which water clerks could assist farmers to determine the amount of water needed for each irrigation, possibly in conjunction with a limited irrigation scheduling program.

Miscellaneous programs which may have promise include some form of measure which would pay farmers to maintain a uniform grade with no more than a predetermined amount of main slope on the lower ends of their fields, and a program which would pay for changing the slope of a field to near dead level.

With these types of incentives and water conservation approaches in mind, the following recommendations are made.

The areas where the greatest influences can be made to conserve water and create greater irrigation efficiency are with the zanjeros and hydrographers, the irrigators, and the farmers who control the irrigators. Both incentive recommendations and water conservation recommendations have, therefore, been directed toward these areas. The above participants are encouraged by making it easier for them to conserve water through incentives, ease in water delivery regulations, and supplying them with the needed data and techniques to accomplish these goals.

Since delivered water-based incentives encourage the use of less water, not just more efficient use of water, the committee recommends against their adoption as regular conservation measures.

S.2.1 Specific Recommendations For Immediate Implementation

A. Irrigation Training

This incentive measure is a combination of training programs for irrigators and briefing sessions for farmers. Farmers and their irrigators will be taught improved scheduling and irrigation techniques.

B. Reduced Irrigation Water Rate/Tailwater Charge

This incentive measure involves the reduction of irrigation water cost to one half of the regular rate ($4.50/AF), but a charge of triple the price of water for tailwater entering through the drainbox ($27.00/AF). This would be a trial program limited to 5,000 acres. Cooperators would be in the program for a minimum of one year or one crop season.

C. Pumpback Standby Charges

It is recommended that electrical standby charges for farmers installing their own pumpback systems or already having their own pumback systems be eliminated.

D. Twelve-hour Runs for Stand Establishment (seed germination through stand establishment)

The charge for the 12-hour runs will be 1-1/2 times the regular cost per acre foot of water.

E. Recommended Changes in the 21-Point Program

Recommended changes in the 21-Point Water Conservation Progam, Points 13 and 14, involve the delaying of the notification time to the District for adjustments in the last 12 hours of the run to 4:30 p.m.

F. Zanjero Training on Water Delivery and Measuring Procedures

The training program now being developed by the District Water Department is supported by the advisory board. The advisory board also recommends its expansion as a means to aid in improving water delivery accuracy.

G. Recommendations on Unauthorized Gate Adjustments

Unauthorized gate adjustments cause fluctuations in delivery and canal spill. When a violation of this rule is discovered it should be rigorously enforced.

S.2.2 RECOMMENDED INCENTIVES FOR FUTURE TRIALS AND STUDY (with the use of water transfer funds)

A. Land Leveling

IID partial payments for land leveling.

B. Water Transfer Money

The allocation of a percentage of the water transfer money to landowers and/or water users for on-farm water conservation measures.

C. IID Personnel for High Tailwater Farmers

Appoint special IID water conservation personnel to work with high tailwater farmers.

D. Farmer/IID Farm Pond/Laterals Soils Trade

E. One-time Payment to Landowner for On-Farm Water Conservation Measures

F. Awards for Exceptional Water Conservation

G. Least Fall Irrigation

S.2.3 ADDITIONAL MEASURES STUDIED BUT NOT RECOMMENDED

A. Inverted rate structure.

B. Reduced water rates for efficiency.

C. Staged rebates for water conservation.

D. Water rates based upon location.

E. District would award credit or payments for no triple charge.

F. IID would not require farmers to supply soil used in the lining of laterals.

G. Combined delivery modification - crop based rebates - tailwater payment/charge plan.

H. On-farm tailwater use for roadways and other needs.

I. Farmer receives the first 4 AF free but pays $20.00 per acre foot for tailwater going out of the tailwater box (a field trial).

CHAPTER 1

CHAPTER 1

INTRODUCTION

1.1 SUMMARY OF PREVIOUS WORK

The long-term commitment by the Imperial Irrigation District and the farmers of the Imperial Valley to water conservation has resulted in improved water delivery, irrigation practices and farming procedures.

It has also improved on-farm water use efficiencies and crop production.

In 1922, the District recognized the need to avoid wasting water and adopted regulations toward this purpose such as Regulation No. 34 in the District Rules and Regulations*. In July 1976, the District added the 13-Point Program (See Appendix A) to its water conservation program. The goal of this program was to improve water use efficiency within the District and reduce inflow to the Salton Sea.

The need to continue and expand water conservation efforts resulted in the District Board of Directors appointing a Water Conservation Advisory Board in 1979. The purpose of this Board is to make recommendations to the District Board of Directors on the implementation of additional water conservation measures.

In 1980, the Water Conservation Advisory Board recommended a 21-Point Program (see Appendix B) to add to the original 13-Point Water Conservation Program for water conservation. This set of rules designed to enhance beneficial use of water was approved by the District Board of Directors in 1980.

Many other water conservation programs developed over the years, and in 1985, the District completed an overall Water Conservation Plan. This was followed by the Water Requirements and Availability Study, the Water Transfer Study, and the Water Conservation Implementation Plan developed for the District by Parsons Water Resources, Inc. The District is also preparing an Environmental Impact Report for the program.

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* Excerpt from Regulation No. 34

...water users wasting water on roads or vacant land, or land previously irrigated, either willfully, carelessly, or on account of defective ditches, or who shall flood certain portions of the land to an unreasonable depth or amount...will be refused the use of water until such conditions are remedied.

Most farmers recognize the need for a method to control tailwater. The tailwater assessment procedure now in force is recognized as necessary for the present, but it is not a very satisfactory or popular program. Both farmers and District personnel recognize the programs shortcomings and have expressed the opinion that there must be a better alternative to improve irrigation efficiency. The Water Requirements and Availability Study in 1985 recommended further studies to investigate water conservation incentive measures and that selected incentives be given field trials.

1.2 PURPOSE OF THE REPORT

In March 1986, the Water Conservation Advisory Board appointed a committee to investigate incentives and other alternatives to encourage water conservation practices in the Imperial Irrigation District.

1.3 THE WATER CONSERVATION ADVISORY BOARD

The Water Conservation Advisory Board is composed of three members from each of five district divisions, appointed by the District Board of Directors. Current members are as follows:

Brad Luckey - Chairman
John Veysey - Vice-Chairman
Vic Barioni
Charles Corfman
Don Cox
Larry Gilbert
Tom Heffernan
Dick Lyerly
Edward Menvielle
J. C. Reeves
Bob Richter
Earl Sperber
George Stergios
Ernie Strahm

1.4 THE INCENTIVE COMMITTEE

The Incentive Committee appointed in March 1986 is composed of the following members:

Brad Luckey - Brawley
Dick Lyerly - Calipatria
Mark Osterkamp - Brawley
Larry Gilbert - Imperial
Bob Richter - El Centro

These members farm both flat crops (using border-strip type irrigation) and row crops.

The committee members were assisted in their evaluation of potential incentive measures by a technical advisory team composed of three representatives of the District (Don Twogood, Doug Welch, and Steve Knell), and two representatives from Parsons Water Resources, Inc. (Richard Palmer and Bob Adam).

1.5 STRUCTURE OF REPORT

1.5.1 Report Organization

The study report is organized into five chapters in addition to the Summary and Appendix.

Chapter 2 presents the incentive measures reviewed along with miscellaneous water conservation ideas presented. They are grouped into five categories to facilitate understanding them. These include services by IID, incentives involving payments, tailwater based programs, incentives involving water rates, and other incentive measures and miscellaneous water conservation ideas presented. Every incentive measure and every water conservation idea presented was considered and is listed for present and future reference.

Chapter 3 involves the evaluation of the incentive measures. The careful selection and weighing procedures for the evaluation criteria are discussed. There is a list of advantages and disadvantages for each incentive. A summary of the costs and benefit analysis and the problems encountered due to the lack of data was discussed.

Chapter 4 presents the conclusions and recommendations. They involve recommended changes to improve water conservation, recommended incentives that can be immediately implemented or tested. The committee also looked at incentives for consideration if water transfer funds become available. Miscellaneous other water conservation ideas were studied but not recommended.

In Chapter 5, implementation is discussed. First, the action needed to start the implementation and testing of the incentives is outlined, pilot demonstration projects and measures are suggested for the current year and for 1987 and in 1987. A final summary of implementation procedures is presented.

1.5.2 Methodology

All incentive measures that could be identified were reviewed without bias. All reasonable approaches in evaluating the incentive measures were explored.

Thirty-one possible evaluation criteria were reviewed and 11 were chosen. The eleven criteria were given a total value of 100%. As some criteria were more or less important than others, it was necessary to weigh some criteria more than the others. The criteria chosen and the relative weights are shown on page 3-1.

Each incentive measure was then reviewed and a list of advantages vs. disadvantages was made to assist the committee in the evaluation.

Very little benefit and cost data was available for many of the incentives; therefore it was decided to go ahead and make assumptions where data was not available. These assumptions, based on the many years of experience of the committee members, were considered strong enough for this screening evaluation. Each incentive was then rated according to the following gradation:

Unacceptable = 0
Poor = 3
Average = 5
Good = 7
Excellent =10

The rating for each criterion was multiplied by the weight of the criterion to give the score of each criteria for each incentive. The scores were added for each incentive alternative to give the total for that alternative. Then the scores for each committee member for each incentive were added to give the final score for the alternative.

After trying this rating procedure, the committee finally decided not to use it. There was insufficient field data present and too many assumptions needed in the benefit and cost analysis to justify the use of many of the B/C ratios.

The study of the costs and benefits, helped the members to become more familiar with the costs, benefits, and other factors involved in the general understanding of the incentives, even though assumptions were used when data was not available.

With this background in studying the advantages and disadvantages of the incentives and water conservation ideas, the process of choosing the criteria, the benefits and costs study, the considerations involved in rating, and their experience in the production and business knowledge involved, the committee had developed a good background to select incentives for pilot studies. In addition, a list was made of incentive measures with merit for future consideration if a water transfer is successful, providing additional funds for the conservation program.

The experience and data developed from this overall study is now presented to the IID Board of Directors for their consideration for future use in water conservation policy.

CHAPTER 2

CHAPTER 2

INCENTIVE MEASURES

2.1 OVERVIEW

Thirty-eight water conservation measures have been received or were developed in committee and have been divided into five incentive categories.

The five categories are as follows:

1. Services by IID
2. Incentives involving payments
3. Tailwater based programs
4. Incentives involving water rates
5. Other incentive measures

Of the 38 measures received and developed, 21 were classified into incentives, four were variations of the incentives, and 13 others were other water conservation measures. These incentives, their variations, and the other water conservation measures are described below:

Potential Incentive	Description
2.2 SERVICES BY IID	
2.2.1 Irrigation Training	This incentive measure is a combination of training programs and information services as follows: (1) Encourage irrigators to attend training courses which include field demonstrations and other sessions on irrigation and water conservation by paying them for time away from work during the training time. (2) Briefings will be made ahead of time to farmers whose irrigators are attending the training courses, on what will be taught. Booklets and leaflets on irrigation and water conservation will be given to farmers. Free irrigation scheduling services will be explained and offered to further optimize irrigation efficiency.

Potential Incentive	Description
2.2.2 Free irrigation scheduling service	The District to provide irrigation scheduling service based on advanced methods. o Neutron probe o Water budget o Evapotranspiration Service would continue as long as recommendations are implemented by the farmer. The water order would be reduced as the tailwater is reduced, but would provide an optimum amount for maximum yields.
2.2.3 Free computer-assisted irrigation scheduling program	The District to provide a computer-assisted irrigation scheduling program using pan evaporation data and IID/farmer supplied data on previous irrigation dates and farmer supplied data on crop/field conditions affecting water use infiltration rates and tailwater on previous irrigations, and the amount of the field to be irrigated.
2.2.4 No standby charges for pumpback systems	Farmers with their own tailwater pumpback systems would not be charged standby costs for electrical power.
2.3 INCENTIVES INVOLVING PAYMENTS	
2.3.1 Partial or full payment for pumpback system	A system of ditches to bring tailwater to a pump and pipes that will convey tailwater back to the head ditch for reuse. District would pay capital costs to install the pumpback system and the farmer would pay for the annual operation and maintenance.
2.3.2 Payment for pumpback systems with reservoir at head of field	Place storage reservoir at upper end instead of lower end.

Potential Incentive	Description
2.3.2 (Continued)	The water in the upper reservoir would be located above ground and could be used to supplement the irrigation stream thereby facilitating labor as well as irrigation. This system would take no more area from production and would conserve water and labor, especially if furrow irrigation was practiced.
2.3.3 Partial payment for land leveling	Partial payment for land leveling to insure good, even distribution of water to each plant in a field and to reduce tailwater.
2.3.4 Incentive payment for level basins	Initial capital cost for level basin preparation would be provided by the water transfer funds.

2.4 TAILWATER BASED PROGRAMS

2.4.1 Tailwater charge/ irrigation water free	Plan (1) The farmer receives the first 4 AF free but pays $20/AF for all tailwater that goes out the tailwater box. Recorders would be used to measure tailwater.
	Plan (2) Farmer receives the first 3 AF free but pays $20/AF for tailwater.
	Plan (3) Farmer receives the first 2 AF free but pays $20/AF for tailwater.
2.4.2 Reduced irrigation water rate/tailwater charge	Plan (1)
	(a) Delivered water is charged at 50% of normal charge (i.e., $4.50/AF).
	(b) Tailwater is charged at triple the delivery rate (i.e., $27.00/AF).

Potential Incentive	Description
2.4.2 (Continued)	(d) Example: Assume 24-hour delivery with a 10-cfs order and 15% tailwater Current system = 10 cfs x 2 x \$9/AF = \$180 charge and 3 AF tailwater. Proposed system = 10 cfs x 2 x \$4.50/AF = \$ 90.00 irrigation water 3 AF x \$27/AF = \$ 81.00 Total = \$171.00 In this example 8.5 cfs of the 10-cfs order is used for the irrigation of the crop. (e) Example: 9 cfs ordered and 5% tailwater 9 cfs x 2 x \$4.50/AF = \$ 81.00 irrigation water 0.90 AF x \$27/AF = 24.30 tailwater Total \$105.30 Therefore, \$171.00 - 105.30 \$ 65.70 savings In this example 8.55 cfs of the 9-cfs order was used for irrigation of the crop. (f) This system would only be installed on a voluntary basis for a specified time period. Plan (2) Plan 2 is the same as Plan (1) except that one half of the cost of tailwater meter would be paid by the farmer and one half would be paid by the District.

Potential Incentive	Description
2.4.3 Crop-based tailwater allowance plan	Plan (1) Allow a specific quantity of tailwater per acre for each specific crop (based on historical data). In this plan, if the quantity of tailwater is less than the allowable, a payment or credit to their account would be earned, whereas tailwater exceeding the allowable limit would be subject to a charge. A step payment charge structure might be considered. Plan (2) Allow a specific quantity of tailwater per acre for each specific crop, based on tailwater data from the IID recorder program. If the quantity of the tailwater is less than the allowable, a payment or credit would be earned. If, however, the tailwater exceeded the allowable limit, a charge would be imposed.
2.4.4 Tailwater charge program	This program is based on an established fixed percentage of tailwater. Example: Allow tailwater at 15%,then charge penalty for every percentage of tailwater over 15% and charge for every percentage under 15%.
2.4.5 Credit for installing permanent 8 inch chokers in tailwater structures	Allow reduction of $1.00/AF in water rate for allowing IID to install the 8 inch choker. $2/AF tailwater assessment would be applied if tailwater structure over-topped.
2.4.6 Credit for installing a 20 inch Restriction weir in tailwater structure	Farmer would receive a credit or rebate of $1/AF for allowing the IID to install a 20 inch steel insert weir in the tail-water box to restrict the drain. The 20 inch weir would not be more than 9 inch below the field. It would flow less than 10 cfs water. The IID would install it and, if requested, would remove it. The restriction weir would be on a voluntary basis for a year at a time.

Potential Incentive	Description
2.4.7 Payment to farmer for water conservation measures	Pay farmer for installing water conservation measures and assess charges if water conservation goals are not reached.

2.5 INCENTIVES INVOLVING WATER RATES

2.5.1 Crop-based water/allocation rebates	Each crop would have a specific amount of water allocated, based on the crop consumptive use and leaching need. Example: If alfalfa were allocated 7 AF/year but only 6 AF/year were used, the farmer would receive the amount of the incentive (e.g., at $10.00) x the AF difference (1 AF) x the acreage (160 acres) = $1,600.00.
2.5.2 Inverted rate structure	Current system 3 AF used = 3 AF x $9/AF = $27.00 4 AF used = 4 AF x $9/AF = $36.00 5 AF used = 5 AF x $9/AF = $45.00 6 AF used = 6 AF x $9/AF = $54.00 7 AF used = 7 AF x $9/AF = $63.00

Plan (1)
1st AF used = $ 4.00 water rate
2nd AF used = $ 6.00 water rate
3rd AF used = $ 8.00 water rate
4th AF used = $10.00 water rate
5th AF used = $12.00 water rate
6th AF used = $14.00 water rate
All after = $20.00 water rate

3 AF used = $18.00
4 AF used = $28.00
5 AF used = $40.00
6 AF used = $54.00
7 AF used = $74.00

Potential Incentive	Description
2.5.2 (Continued)	To execute this plan, it would be necessary to know the acreage served by each farm delivery, and to bill accordingly, probably on an annual basis.
	Plan (2) 1st AF used = \$ 3.00 water rate 2nd AF used = \$ 6.00 water rate 3rd AF used = \$ 9.00 water rate 4th AF used = \$12.00 water rate 5th AF used = \$15.00 water rate 6th AF used = \$17.00 water rate All after = \$20.00 water rate
	3 AF used = \$18.00 4 AF used = \$28.00 5 AF used = \$40.00 6 AF used = \$64.00 7 AF used = \$85.00
	To execute this plan, it would be necessary to know the acreage served, by each farm delivery, and to bill accordingly, probably on an annual basis.
2.5.3 Reduced rate for efficiency	Water rates based on the present efficiency as follows:
	(1) Savings for farmer
	(Water value to farmer = \$9/AF)
	For 0% water savings, charge is \$9/AF = 0 savings 5% water savings, charge is \$8.55/AF = \$0.45 savings 10% water savings, charge is \$8.10/AF = \$0.90 savings 20% water savings, charge is \$7.20/AF = \$1.80 savings 30% water savings, charge is \$6.30/AF = \$2.80 savings 40% water savings, charge is \$5.40/AF = \$3.60 savings
	(\$0.45 increments per each 5% water saved)

Potential Incentive	Description

2.5.3 (Continued)

Example: water use = 600 AF
Using the present water Cost of $9/AF x 600 AF = $5,400
If 20% of the water is conserved, 600 AF - 120 AF (20% of 600 AF) = 480 AF.
The savings = 480 AF x $7.20/AF = $3,450
Resulting in a cost savings of 36% ($5,400 - $3,450 = $1,950)

(2) Savings for IID

(Water value to IID = $100/AF)

For 0% water benefit is $0/AF
5% water benefit is $5/AF and for 500 A = $ 2,500
10% water benefit is $10/AF and for 500 A = $ 5,000
20% water benefit is $20/AF and for 500 A = $10,000
30% water benefit is $30/AF and for 500 A = $15,000
40% water benefit is $40/AF and for 500 A = $20,000

(Administration costs would reduce these benefits)

2.5.4 Staged rebates for water conservation

Levels of rebates would be based on the amount of water conserved as follows. The quantity of water conserved would be determined by historical performance.

Water Saved	Rebates in $/AF
1st foot	4
2nd foot	6
3rd foot	8
4th foot	10
5th foot	12
6th foot	14

2.5.5 Water rates based on location

Water rate structure based on the cost to deliver water to the user (i.e., service cost).

Potential Incentive	Description
2.5.6 12 hour delivery for seed germination through stand establishment	This incentive measure involves a program to allow users to order not more than 4 cfs of water for either the last or first 12 hours of the delivery day at a price of 1-1/2 times the normal charge for water received.

2.6 OTHER INCENTIVE MEASURES AND NON-INCENTIVE WATER CONSERVATION IDEAS

2.6.1 Monetary incentive to a farmer and/or irrigator for no triple charges	District would award credit or payments for no triple charges.
2.6.2 Farmer incentive for District lateral lining	To promote canal lining of District laterals, a "no soil" incentive would be provided in this plan since soil is presently required from farmers for the lining of laterals.
2.6.3 Farmer/District soil/pond trade	In this plan, the District would excavate a pond for the farmer to use in a pumpback system, storage, or other conservation measure in return for using the excavated soil for the lining of laterals.
2.6.4 Allocation of water transfer funds	This plan involves a percentage of the water transfer money to be allocated to the landowner and/or water user for on-farm water conservation measures: (a) A minimum of 51% of the water transfer money would be used to establish a fund for landowner use. For example: For a $10 million transfer, $5.1 million would be allocated. (b) This is equivalent to approximately $10/acre, based on 510,000 acres. Farmers would be eligible for this program only if they made water-availability payments over the last 5 years.

Potential Incentive	Description
2.6.5 Awards for exceptional water conservation	Dinners, awards, plaques, publicity for exceptional water conservation.
2.6.6 Licensed irrigators	In the program, only trained, tested, and licensed irrigators would be permitted to work under the supervision of the individual farmer or a private contractor. The irrigator would be permitted to operate IID's gates within limitations and proper notification to the District for minor changes only. If more flexible schedules were developed by the IID, the irrigator could operate gates on allocated days with notification to the IID or some other equivalent arrangement.
2.6.7 Least fall irrigations	Make furrows down the direction of the least fall to obtain greatest leveling effect without actually leveling. Better leveling equals less tailwater problems.
2.6.8 Educational publications to farmers	District to obtain and distribute educational publications on water conservation to farmers: pamphlets, booklets, leaflets, etc.
2.6.9 Increase IID water conservation personnel for work with high tailwater farmers	Assign IID personnel to work with high tailwater farmers.
2.6.10 On-farm tailwater use	Distribute tailwater on-farm for roadway spraying
2.6.11 Stabilizing gate or weir	Develop water pressure stabilizing gates or weirs behind the delivery gates.
2.6.12 Zanjero training	Develop a training program for zanjeros on water delivery and water measuring procedures.

Potential Incentive	Description
2.6.13 Delay in time IID is notified to reduce the water order	Points 13 and 14 of the 21-Point water conservation program would be changed to allow a farmer who wanted to adjust his order for the last 12 hours water is run, to notify the District in advance but not later than 4:30 p.m. A more detailed description of the change will be presented in Chapter 4, Conclusions and Recommendations.

CHAPTER 3

CHAPTER 3

EVALUATION

3.1 CRITERIA

The preliminary 11 criteria chosen to evaluate the incentives were considered major factors to the success of the incentives. They were given a total value of 100%, with each criteria weighted according to the value placed upon it by the committee.

The initial 11 criteria and their weights are listed below:

CRITERIA CHOSEN		Weight (%)
1.	Benefit/cost ratio for farmers	25
2.	Benefit/cost ratio for IID	15
3.	Degree farmer is able to control the factors necessary to receive the incentive	11
4.	Water conserved	10
5.	Ease of administration	9
6.	Lag-time (implementation to benefits)	7
7.	Farmer acceptance (by crop)	6
8.	Compatibility with other incentives	5
9.	Predictability of incentive	5
10.	Farmer acceptance (by location)	4
11.	Implementation time	3
	TOTAL (%)	100

3.2 BENEFITS AND COSTS

The two major criteria with the greatest weights in the evaluation of the incentive measures were:

(1) Benefits and costs to farmers

(2) Benefits and cost to IID

A large amount of work was done analyzing the economics of these criteria. There was very little data available on which to base the costs and benefits of most of the incentives. Only assumptions could be made, in most cases, to estimate the benefits and costs. The data was thoroughly reviewed by the committee, who finally decided that so many assumptions were needed that the data should not be used in the report. These calculations, therefore, are not included in this report. Later when field trials of recommended incentives have been completed, there will be more meaningul data available.

The only other approach to analyze the incentives and the procedure that was carried out was the one described in the following section.

3.3 SELECTION OF INCENTIVE MEASURES

The preliminary plan to evaluate the incentives by rating each criteria for each incentive and multiplying it with its weight and adding up the incentive score was not used to select the incentives. As costs and benefits data was not available, the selection of the incentive was based upon the experience and judgement of individual committee members.

The basis for the selections was the thorough understanding of both the farming requirements and practices along with water delivery by the farmers and the District.

The committee made a detailed study of each incentive measure. A list of advantages and disadvantages was made of every incentive measure other than the duplicate incentives submitted. Although the benefits and costs study was not used, the process of examining the economics of the incentives by the committee further broadened their knowledg of the incentives. The process of choosing the eleven criteria from 31 other criteria increased the Committees' understanding of each incentive. The procedures used in weighting criteria to ensure their fair values was also effective. The recommendations for the incentives and the other water conservation measures were carefully thought out and based upon the above factors.

Following is a detailed listing of the advantages and disadvantages of the incentive measures.

3.3.1 SERVICES BY IID

PAYMENT TO IRRIGATOR WHILE ATTENDING A WATER CONSERVATION TRAINING PROGRAM.

Advantages	Disadvantages
1. This incentive affects a key participant in water conservation (the irrigator).	1. Program will cost $4.00 to $5.00 per hour to IID per irrigator per course.
2. It also influences the farmer to allow the irrigator to attend.	2. Some farmers will want to train their own irrigators.
3. The incentive trains and encourages the irrigator to conserve water.	3. Only benefits irrigators, no monetary incentive to farmer for loss of worker.
4. Payment replaces wages irrigator would lose during the training course.	4. Training does not guarantee that irrigator will conserve water.
5. Possibility of increased wages for a more efficient irrigator.	
8. Possibility of increased irrigation efficiency (i.e, reduced tailwater).	
7. Inexpensive to IID.	

FREE IRRIGATION SCHEDULING SERVICE

Advantages	Disadvantages
1. Encourage more efficient use of water.	1. High cost to District.
2. Reduced water orders due to reduced tailwater as a result of increased irrigation efficiency.	
3. Will increase knowledge of irrigator and farmer in irrigation scheduling techniques.	
4. Free irrigation scheduling will continue as long as farmer participates.	

FREE COMPUTER ASSISTED IRRIGATION SCHEDULING PROGRAM.

Advantages	Disadvantages
1. Encourages more efiicient use of water.	1. Costly to District
2. This measure can increase irrigation efficiency resulting in a reduction in tailwater outflow. This will result in reduced water orders.	2. Data is based upon historical data rather than on current climatic

NO STANDBY CHARGES FOR PUMPBACK SYSTEMS.

Advantages	Disadvantages
1. Reduced O&M cost for farmer.	1. Increased O&M cost to IID.
2 Encourages installation of pumpback systems.	

3.3.2 INCENTIVES INVOLVING PAYMENTS

PARTIAL OR FULL PAYMENT FOR PUMPBACK SYSTEMS.

Advantages	Disadvantages
1. Tailwater is reused or stored if sump is large enough.	1. Additional O&M costs.
2. Tailwater discharge is eliminated or reduced.	2. Potential salinity and temperature problems.
3. Irrigation water is conserved.	
4. There is more irrigation application flexibility.	
5 The estimated benefit/cost ratio is 1.59.[1]	
6. High rate of water conservation predictability.	

[1] Source: Parsons, 1985

PAYMENT FOR PUMPBACK SYSTEM WITH GRAVITY IRRIGATION STORAGE RESERVOIR AT HEAD OF FIELD.

Advantages	Disadvantages
1. Tailwater is reused or stored and reused as needed.	1. Additional O&M costs.
2. Tailwater discharge into drains is eliminated or reduced.	2. Potential salinity and temperature problems.
3. Gravity flow irrigation water gives greater flexibility.	3. Pump size must be increased.
4. Irrigation water is conserved.	4. Increased cost.
5. The estimated benefit/cost ratio is 1.50.[1]	

PARTIAL PAYMENT FOR LAND LEVELING.

Advantages	Disadvantages
1. Good land leveling is a major factor in the even distribution of water to each plant.	1. Major land leveling is costly, especially in areas where the grade is steep.
It is essential to good water efficiency and low tailwater runoff.	2. There are some areas where this measure is not practical.
2. Even water distribution can increase yields if the proper amount of water is applied.	3. Not fair to farmers who have already leveled their land.
3. It can result in reduced tailwater, thereby conserving water.	
4. The estimated benefit/cost ratio is 1.23[1]	

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[1]Source: Parsons, 1985.

PAYMENT FOR DEAD LEVELING.

Advantages	Disadvantages
1. Dead leveling gives optimum level for water control.	1. Dead leveling (no slope) can be costly.
2. It can increase yields if previous slope was faulty.	2. It is limited in its application to both slope and soil.
3. It can result in no tailwater, thereby conserving optimum amounts of water.	3. Delivery system must be improved.
	4. Unfair incentive to farmers who have already paid for dead leveling.

3.3.3 TAILWATER BASED PROGRAMS

TAILWATER PAYMENT/IRRIGATION WATER FREE.

Advantages	Disadvantages
PLAN A	
1. Farmer receives first 4 AF water per acre free. Water thereafter is at 9/AF.	1. Farmer pays $20/AF for all tailwater going out the tailwater box.
2. Advantage to low water users such as vegetable growers.	2. First 4/AF/A free to farmers would leave IID without O&M or improvement capital.
	3. Tailwater recorders would be required on every tailwater box. High capital O&M cost to District.
	4. Disadvantage to high water users such as alfalfa growers.
	5. There is no incentive to use less than 4 AF water in Plan A.
PLAN B	
1. Farmer receives first 3 AF water per acre free. Water thereafter is at $9/AF.	1. All disadvantages in Plan A apply in Plan B except that the farmer receives 1 AF less free water than in Plan A.
2. Advantage to low water users such as vegetable growers.	
3. Plan B is more favorable to IID, and one acre foot less favorable to the farmer (by whatever the water cost would be at that time).	

TAILWATER PAYMENT/IRRIGATION WATER FREE. (Cont'd)

Advantages	Disadvantages
PLAN C	
1. Farmer receives first 2 AF water per acre free. Water thereafter is at $9/AF.	1. All disadvantages in Plan A apply in Plan C except that the farmer receives 2 AF less free water than in Plan A.

REDUCED IRRIGATION WATER RATE/TAILWATER PAYMENT

Advantages	Disadvantages
1. Reduced irrigation water costs to farmer by $4.50/AF	1. Tailwater charge would be $27/AF for farmers.
2. Reduced tailwater due to increased tailwater charges.	2. High cost associated with tailwater recorders to IID.
3. This measure does not require measuring devices at the head gates.	3. Decreased income to IID from water revenues.
4. Water cost is weighted heavily on tailwater, an advantage for water conservation.	

CROP BASED TAILWATER ALLOWANCE (based on historical data).

Advantages	Disadvantages
PLAN A	
1. Increased fairness of tail-charge.	1. Historical data is not available.
2. Accurate tailwater charges since recorders would be used.	2. High cost involved in installing tailwater recorders.
3. Encourage water conservation.	3. Difficult to determine tailwater allowances for each crop.
4. Payment or credit to farmer for reducing tailwater below crop allowance.	4. Difficult to determine the crop from which the tailwater came.
5. Increased tailwater charges to high tailwater farmers.	

CROP BASED TAILWATER ALLOWANCE (based on tailwater data from IID recorder Program).

Advantages	Disadvantages
PLAN B	
1. Increased fairness of tailwater charge.	1. High cost involved in installing tailwater recorders.
2. Accurate tailwater charges since recorders would be used.	2. Difficult to determine tailwater allowances for each crop.
3. Encourage water conservation.	3. Difficult to determine the crop from which the tailwater came.
4. Payment or credit to farmer for reducing tailwater below crop allowance.	
5. Increased tailwater charges to chronic water wasters.	

TAILWATER PAYMENT/CHARGE PROGRAM.

Advantages	Disadvantages
1. Tailwater charges would be made according to the amount of water wasted. It, therefore, encourages less tailwater.	1. Program as written does not allow varying tailwater percentages for different crops.
	2. It would not encourage water conservation below 15%.

CREDIT FOR INSTALLING 8 INCH CHOKERS IN TAILWATER PIPES

Advantages	Disadvantages
1. Encourages reduction in tailwater.	1. Cost to IID for Purchasing and installing 8 inch. chokers.
2. Reduced water rates.	2. Reduced revenue to IID from reduction in water rates.
	3. Potential for crop damage due to restriction of tailwater flows.

CREDIT FOR INSTALLING A 20 INCH RESTRICTION WEIR IN THE TAILWATER STRUCTURE.

Advantages	Disadvantages
1. Encourages reduction in tailwater. 2. Reduced water rates. 3. Improvement over incentive measure 5.	1. Cost to IID for purchasing and installing 20 inch restriction weir in the tailwater structure. 2. Reduced revenue to IID from reduction in water rates. 3. Potential for crop damage due to restriction of tailwater flow if tailwater is above 15-20%.

PAYMENT TO FARMER FOR WATER CONSERVATION MEASURES.

Advantages	Disadvantages
1 Encourages farmer to install water conservation measures. 2. Encourages farmers to keep tailwater at a preagreed percentage. 3. It allows the farmer an option in choosing the incentive measures. 4. It is fair and equitable.	1. The payment amounts determine the economic viability of the measure. 2. Benefits variable.

3.3.4 INCENTIVES INVOLVING WATER RATES

CROP-BASED WATER REBATES.

Advantages	Disadvantages
1. Fair to all crop growers.	1. Costs involved in providing more accurate deliveries.
2. Conserves water by decreasing the over ordering of water by farmers.	2. Possible decrease in income to IID.
3. Does not necessarily require recorders.	3. Needs additional measurements at night, therefore, needs more personnel.

INVERTED RATE STRUCTURE

Advantages	Disadvantages
PLAN-A	
1. Substantial reduction in water costs to low water users.	1. Decreased water revenues for IID due to low water rates for water usage under 5 AF.
2. It encourages water conservation.	2. Plan A as stated is considered economically unreasonable for IID.
3. Minimal cost to implement.	3. Penalizes high water users in excess of 6 AF water orders.
	4. Does not encourage more efficient use of water as it is written.
	5. Farmers growing low water-use crops will not have an incentive to conserve water.

INVERTED RATE STRUCTURE.

Advantages	Disadvantages
PLAN B	
1. Reduced water costs for farmers ordering water under 5 AF.	1. Penalizes high water users particularly alfalfa growers. Alfalfa growers would pay $10/AF more for a 6 AF order than they are normally paying.
2. Encourages high water users to conserve water through decreased water orders.	2. Farmers growing low water using croPs will not have an incentive to conserve water.
3. Should not have a negative impact on revenues for IID.	
4. Minimal cost to implement.	

REDUCED RATE FOR EFFICIENCY.

Advantages	Disadvantages
1. Encourages water conservation by decreasing water orders.	1. Determination of water savings for each farmer would require historical water use and crop type for each farmer (i.e., extensive bookeeping by IID).
	2. High administration costs.
	3. Decreases water revenues for IID.
	4. Unfair to those farmers already conserving water.
	5. Difficult to implement by IID.
	6. Unjust monetary advantage to high tailwater farmers.

STAGED REBATES FOR WATER CONSERVATION.

Advantages	Disadvantages
1. Levels of rebates to farmers would be $4, $6, $8, $10, etc., for 1st, 2nd, 3rd, 4th, etc., AF of water saved, reducing the cost of water to the farmer.	1. The quantity of water conserved is based on historical performance. 2. Historical performance is not always available. It does not reward the farmer who is already conserving water. 3. It requires the high cost of recorders.

WATER RATES BASED ON LOCATION.

Advantages	Disadvantages
1. Decreased water costs to users located closest to supply.	1. Increased water costs to users located farther away from supply. 2. Additional administrative costs (record keeping).

TWELVE HOUR DELIVERY FOR SEED GERMINATION THROUGH STAND ESTABLISHMENT.

Advantages	Disadvantages
1. This incentive allows farmers to conserve water when irrigating for seed germination through stand establishment. It is a definite incentive to encourage the farmer to carefully use water during this seed germination/stand establishment period. Considerable amounts of water now lost during this time can be saved if this incentive is activated.	1. Overall increase in number of zanjeros and hydrographers.
2. The cost of the extra zanjero is covered by the 1-1/2 times the regular water cost.	2. Increased cost of operations.

3.3.5 OTHER INCENTIVE MEASURES AND NON-INCENTIVE WATER CONSERVATION IDEAS

MONETARY INCENTIVE TO A FARM AND/OR IRRIGATOR FOR NO TRIPLE CHARGES.

Advantages	Disadvantages
1. Encourages water conservation.	1. Care must be carefully exercised in choosing the award to be given to the farmer. 2. Can be costly to IID. 3. Tailwater assessment is not necessarily an indication of excessive tailwater.

FARMER INCENTIVE FOR DISTRICT LATERAL LINING.

Advantages	Disadvantages
1. The farm land along the canal to be lined would not be disturbed.	1. Increased cost over obtaining soil from the farm land in question.

FARMER/DISTRICT SOIL/POND TRADE

Advantages	Disadvantages
1. The District would obtain soil for the lining of the laterals. 2. The farmer would in turn have a pond excavated for a pumpback system or other conservation measure.	1. The trade situation must be present.

PAYMENT TO LANDOWNER FOR INSTALLING WATER CONSERVATION MEASURES AND ASSESSES CHARGES IF WATER CONSERVATION GOALS ARE NOT REACHED.

Advantages	Disadvantages
1. Encourages water conservation. 2. Water conservation measures can increase the value of the farm. 3. Water conservation measures can result in less production costs.	1. This measure gives a monetary inducement in addition to receiving the water conservation measure free of charge. This is a costly double monetary inducement for a single incentive.

ALLOCATION OF WATER TRANSFER FUNDS FOR ON-FARM WATER CONSERVATION MEASURES.

Advantages	Disadvantages
1. This Plan provides 51 percent of the water transfer money to be allocated for on-farm water conservation measures and result in a more efficient irrigation system.	1. The use of 51 percent of the water transfer money for on-farm water conservation measures reduces the money that could be used for off-farm measures such as reservoirs, canal lining, etc.
2. Water will be conserved.	
3. Greater irrigation efficiency can result in improved yields and greater profits.	

AWARDS FOR EXCEPTIONAL WATER CONSERVATION.

Advantages	Disadvantages
1. Public recognition of water conservation.	1. It is difficult to choose those to be recognized and could cause touchy diplomacy.
2. Encourages water conservation.	

ONLY TRAINED, TESTED, AND CERTIFIED IRRIGATORS WOULD BE PERMITTED TO WORK UNDER THE SUPERVISION OF THE FARMER OR A PRIVATE CONTRACTOR.

Advantages	Disadvantages
1. The measure would result in the conservation of water by improving and certifying the training of irrigators.	1. This measure could cause a significant increase in the cost of irrigation for the farmer.
	2. It is a restrictive measure to a beginning irrigator trying to obtain work.
	3. Some growers are concerned about the possibility of the measure creating labor problems.
	4. Allowing the trained and certified irrigator to operate gates on allocated days with notification to the IID could result in operation problems.

LEAST FALL IRRIGATION; MAKE FURROWS DOWN THE DIRECTION OF THE LEAST FALL TO OBTAIN THE GREATEST LEVELING EFFECT WITHOUT ACTUALLY LEVELING.

Advantages	Disadvantages
1. Improved water control from lessening the fall can result in less tailwater, thereby conserving water.	1. It is difficult to irrigate a field where every run has a different length. This difficulty causes more work and greater distraction for the irrigator. It could create more irrigation mistakes and result in even more tailwater losses.

DISTRIBUTE EDUCATIONAL PUBLICATIONS.

Advantages	Disadvantages
1. Any educational material on improved irrigation techniques and water conservation can create improved efficiency and conserve water.	
2. This water conservaton idea can be combined with other incentive measures.	

ASSIGN IID PERSONNEL TO WORK WITH HIGH TAILWATER FARMERS.

Advantages	Disadvantages
1. Close contact between these specially assigned water conservation personnel and high tailwater farmers needs to be combined with good incentive measures. This combination can be very effective in conserving water.	1. The cost of extra IID personnel.

DISTRIBUTE TAILWATER ON-FARM FOR ROADWAY SPRAYING AND OTHER APPLICATIONS.

Advantages	Disadvantages
1. Tailwater used for roadways is tailwater that does not create problems by going down the drain.	1. The most efficient way to control tailwater spills is by improving irrigation efficiency. The use of tail-water for on-farm roadways and similar needs will control only a small amount of the tailwater problem.

APPOINT AN IID BOARD WHO WOULD REVIEW AND
APPROVE ALL INCENTIVE APPLICATIONS AND PAYMENTS.

Advantages	Disadvantages
1. The board would act as a neutral group to ensure fairness in the approvals of the incentive applications payments.	

DEVELOP WATER PRESSURE STABILIZING GATES
OR WEIRS BEHIND THE DELIVERY GATES.

Advantages	Disadvantages
1. Prevents erratic water surface elevations. This will give more accurate water measurements.	1. Existing head is already low in some cases.

CHAPTER 4

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 INTRODUCTION

The Committee in its study of the 38 measures identified, concluded that tailwater-based incentives provide the specific incentive to increase efficiency and reduce losses, which is the primary goal of water conservation. A major disadvantage to most such programs is the cost of measuring tailwater to verify that goals are attained ($6-$7 million/yr). This fixed cost is very large per acre foot unless large quantities are saved. For example, if 50,000 AF are saved it amounts to $130/AF, if 100,000 then $65/AF, if 150,000 then $43/AF, if 200,000 then $33/AF. Tailwater is variously estimated between 300,000 and 400,000 AF/year. These figures do not include the cost of changes to the IID's system and procedures, which might be necessary before farmers could reduce tailwater by significant amounts. Specifically, changes would be needed to permit deliveries to more closely match field use, either by employing techniques which would greatly improve the accuracy of ordering and delivering water, or by modifying the delivery system and its operation to allow deliveries to be terminated at the time field needs are satisfied, without canal spills.

The two most promising types of tailwater-based programs are; one which pays a farmer for reducing tailwater within predetermined parameters and allows him to employ whatever means he chooses and to save as much water as is economically feasible; and one which pays a farmer for effectively operating a pumpback system to predetermined specifications.

Programs which provide a service to farmers and which would make it practical for them to conserve water without additional expense would also result in additional conservation. Services which are worthy of additional consideration include an irrigator training program, a program to train zanjeros and other appropriate water personnel, and a program by which water clerks could assist farmers to determine the amount of water needed for each irrigation, possibly in conjunction with a limited irrigation scheduling program.

Miscellaneous programs which may have promise include some form of program which would pay farmers to maintain a uniform grade with no more than a predetermined amount of main slope on the lower ends of their fields and a program which would pay for changing the slope of a field to near dead-level.

With these types of incentives and water conservation approaches in mind, the following recommendations are made.

4.2 RECOMMENDED WATER CONSERVATION MEASURES

The areas where the greatest influences can be made to conserve water and create greater irrigation efficiency are with the zanjeros and hydrographers, the irrigators, and the farmers who control the irrigators. Both incentive recommendations and water conservation recommendations have, therefore, been directed toward these areas. The above participants are encouraged by making it easier for them to conserve water through incentives, ease in water delivery regulations, and supplying them with the needed data and techniques to accomplish these goals.

4.3 RECOMMENDATIONS FOR IMMEDIATE IMPLEMENTATION OR FOR TRIAL

Resolution No. 86-1, adopted by the Water Conservation Advisory Board on August 7, 1986 recommended seven incentive measures for consideration by the District Board of Directors.

1. Irrigation Training
2. Reduced Irrigation Water Rate/Tailwater Charge
3. Pumpback Standby Charges
4. Twelve Hour Runs for Stand Establishment
5. Recommended Changes in the 21-Point Water Conservation Program
6. Zanjero Training on Water Delivery and Measuring Procedures
7. Unauthorized Gate Adjustments

4.4 ADDITIONAL MEASURES STUDIED BUT NOT RECOMMENDED FOR IMMEDIATE IMPLEMENTATION, UNLESS OUTSIDE FUNDING AVAILABLE

1. Land Leveling

IID partial payments for land leveling.

2. Water Transfer Money

   The allocation of a percentage of the water transfer money to landowers and/or water users for on-farm water conservation measures.

3. IID Personnel for High Tailwater Farmers

   Appoint special IID water conservation personnel to work with high tailwater farmers.

4. Farmer/IID Farm Pond/Laterals Soils Trade

5. One-time Payment to Landowner for On-Farm Water Conservation Measures

6. Awards for Exceptional Water Conservation

7. Least Fall Irrigation

4.5 ADDITIONAL MEASURES STUDIED BUT NOT RECOMMENDED

1. Inverted rate structure.

2. Reduced water rates for efficiency.

3. Staged rebates for water conservation.

4. Water rates based upon location.

5. District would award credit or payments for no triple charge.

6. IID would not require farmers to supply soil used in the lining of laterals.

7. Combined delivery modification - crop based rebates - tailwater payment/charge plan.

8. On-farm tailwater use for roadways and other needs.

9. Farmer receives the first 4 AF free but pays $20.00 per acre foot for tailwater going out of the tailwater box (a field trial).

CHAPTER 5

CHAPTER 5

IMPLEMENTATION

5.1 ACTION BY THE IID BOARD

After the incentive and other water conservation recommendations submitted to the Water Conservation Advisory Board are approved, they must then be presented to the IID Board of Directors for consideration and action.

5.2 PILOT DEMONSTRATION PROJECTS/MEASURES

5.2.1 Current Measures

The incentive measures recommended for adoption include the Irrigation training Program, the Pumpback Standby Charges, the Twelve Hour Runs for Stand Establishment, and the Reduced Irrigation Water Rate/Tailwater Charge field trials. Other water conservation measures recommended for adoption include changes in the 21-Point Water Conservation Program, Zanjero Training on Water Delivery and Measuring Procedures, Recommendations on Unauthorized Gate Adjustments.

5.2.2 Incentives For Future Trial And Study

As water transfer or other funds become available, the incentives in this group should be re-evaluated and implemented if justified.

5.2.3 Evaluation

Incentives implemented should be evaluated on a timely basis. If an incentive proves to be worthwhile, district-wide implementation should be considered. If no benefits can be determined the incentive measure should be terminated.

5.2.4 Funding/Budget

Funding of the incentive measures should be included as part of the Water Conservation Implementation Plan, currently under preparation, and in the District's annual budget.

APPENDIX

APPENDIX A

IMPERIAL IRRIGATION DISTRICT 13-POINT PROGRAM FOR WATER CONSERVATION

Point	Description	Targeted Water Loss Reduction
1	Construct water regulating reservoir on Westside Main Canal	Operational spills
2	Reconstruct farm outlet boxes, as required	Tailwater runoff
3	Assign adequate water regulating personnel to provide more efficient deliveries	Tailwater runoff and operational spills
4	Conduct daily inventory of surface field discharge and charge users who waste water an assessment for that day equal to three times the scheduled water rate	Tailwater runoff
5	Develop surface water evaporation ponds	Inflow to Salton Sea
6	Conduct preliminary studies for a regulating reservoir on Central Main Canal	Operational spills
7	Conduct study of the water recovery lines paralleling the East Highline and Westside Main Canals to recover seepage that is now going into the drainage system and the Salton Sea	Canal Seepage
8	Provide free drainage water to persons willing pump and use it	Inflow to Salton Sea
9	Continue the concrete lining program	Canal Seepage
10	Initiate a record of accrued water use by computerized billing	Tailwater Runoff
11	Install radio equipment in all water conservation-related vehicles to provide immediate communication	Tailwater runoff and operational spills
12	Initiate irrigation management services program	Tailwater runoff
13	Deliver water off-schedule when possible	Tailwater runoff

APPENDIX B

21-POINT WATER CONSERVATION PROGRAM

The 21-Point Water Conservation Program recommended by the Water Conservation Advisory Board and adopted by the District Board is set forth as follows:

(1) The District shall establish a penalty of $100.00 for the unauthorized adjusting of delivery gates, which results in a change in the amount of water being delivered. Furthermore, whenever a water order is in the process of being pumped through a sprinkler or gated pipe system and the operator-user experiences a mechanical failure of the subject equipment, said operator-user shall be permitted to discontinue his water delivery for a period of not more than 3 hours. The free time permitted under this schedule shall be considered as separate instances, but in no event shall the combined hours so considered exceed 3 hours before a triple charge is to be assessed.

(2) The concept of installing gate control devices of a standard design is recommended and supported, such devices to be installed on structures accommodating gates that are owned, operated and maintained, as well as regulated, under the jurisdiction of the District and its personnel.

(3) Application of the assessment charge shall apply on the same basis to all types of irrigation, with the following exceptions.

   (a) The percentages of surface runoff allowed when water is being used to irrigate plowed or flat unseeded ground shall be 5 percent for the last day of said irrigation, no measurable waste shall be allowed for any previous days.

   (b) When water is being run in furrows to germinate crop seeds and establish a stand, no assessment charge shall be made unless one of the two consecutive measurements showing 15 percent or more runoff is made between 12:00 noon and 6.00 p.m.

(4) In the event a water user is receiving more than his confirmed order, said surplus shall be subtracted from his surface runoff for the purpose of determining if his runoff is excessive.

(5) In no event shall any water user be assessed unless his runoff is 15% or more of his running order irrespective of the quantity of water the user is receiving.

(6) Any surface runoff measurement made within 4 hours after the District has reduced the quantity of water delivered shall apply to the order in effect before said change.

(7) The application of an assessment charge based on waste measured after the delivery gate is closed shall apply on the same basis as when water was actually running. Any assessment made after the gate is closed shall be based on the order last running.

(8) In no event shall the user pay more than triple the normal charge for water, except when he adjusts the delivery gate without permission.

(9) All net proceeds from surface runoff assessment charges shall go into a special fund for conservation purposes other than the concrete lining of ditches.

(10) All District personnel whose duties include checking of surface runoff will initial any waste assessment sheet issued.

(11) Changes can be made for the last day of a run by notifying the District not later than 3:00 p.m. of the preceding day.

(12) When a water user requests an adjustment in the quantity of water delivered not to exceed 2 ft^3/s, the District shall be obliged to honor the same if it is within the ability of the District's system to accommodate such a request and if the water user notifies the zanjero in advance of beginning his daily run. The zanjero of said run shall obtain approval to make said change from his respective superior or section.

(13) A reduction in the water order shall be made to apply to the last 12 hours water is run, providing that the District is notified in advance but not later than 3:00 p.m. preceding the time the order is changed. No penalty shall be charged for said reduction as long as the same does not exceed 50 percent or 5 feet of the order as confirmed, whichever is less. Water that is returned with notice after 3:00 p.m. or that exceeds the quantity that this rule authorizes shall be subject to an assessment equal to two times the regular water rate.

(14) By notifying the District before 3:00 p.m., orders can be adjusted for the last 12 hours of the run up to 50 percent of the confirmed order or 5 ft /s whichever is less.

(15) Finish heads can be ordered up to 3:00 p.m. of the day preceding the day of delivery.

(16) By notifying the District before 7:30 a.m. of the last day of a run, an order can be adjusted up to 50 percent, without penalty.

(17) One-day orders shall be checked by the appropriate District employees on the same basis as any other water order. For the application of the assessment charge, the first waste measurement shall not be made later than 18 hours after the beginning of the day's water delivery.

(18) The District shall secure whatever additional radio equipment is necessary to improve communications between the farmers and Water Department personnel.

(19) The Water Department of the District shall make 6 waste water recorders available to be installed at various locations within the service area boundaries as defined.

(20) The District shall prepare a monthly water information bulle- for distribution that shall include information submitted to the District by a committee to be appointed by the Water Conservation Advisory Board and from other sources as required to assist the water user in using all water beneficially.

(21) Routine canal cutouts shall be accomplished once every 8 weeks, except when special circumstances require more frequent cut-outs.